Large Anomalous Hall Effect in a Silicon-Based Magnetic Semiconductor

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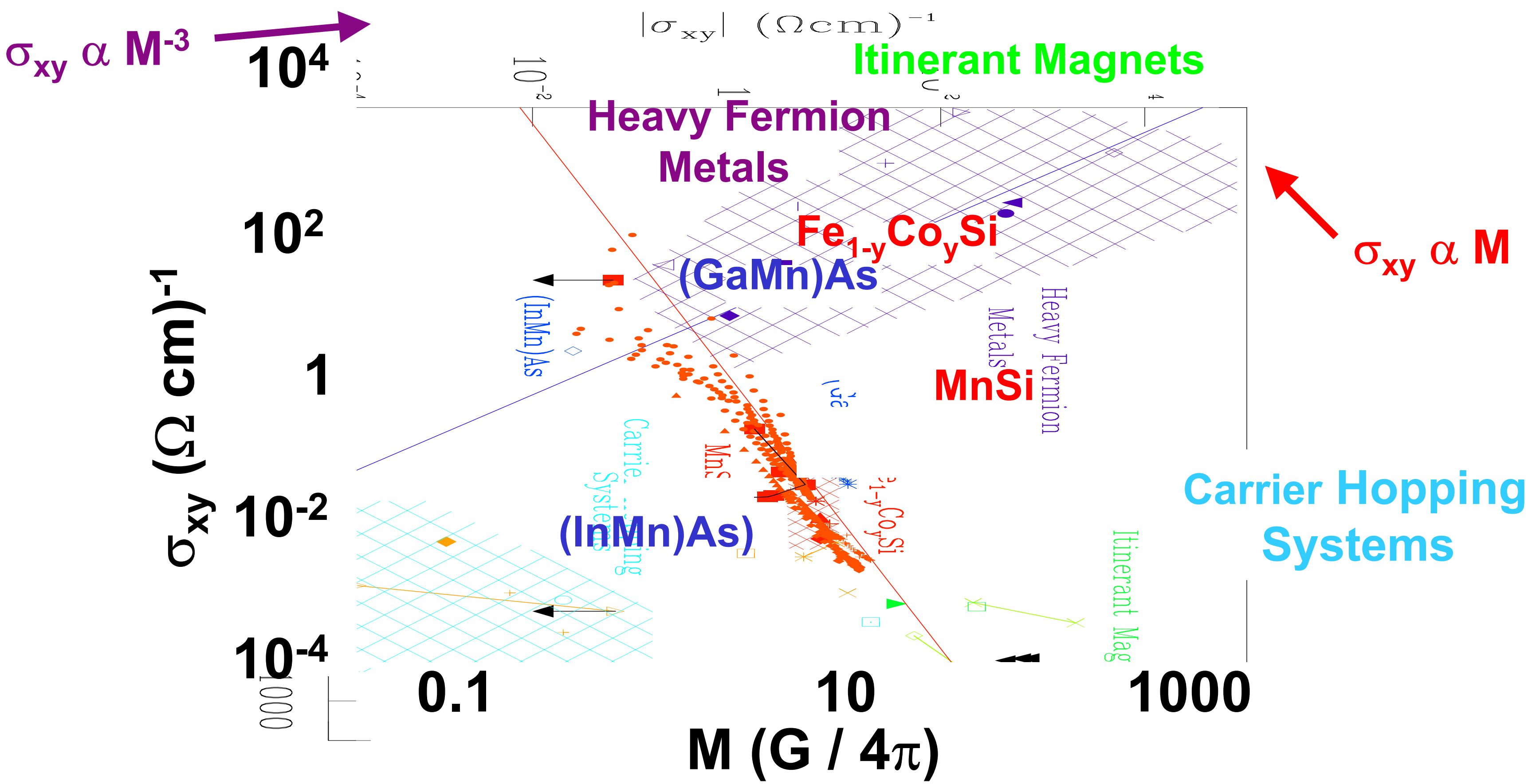

Magnetic Semiconductors are attracting high interest because of their potential use for spintronics. We have shown that a transition metal monosilicide $Fe_{1-x}Co_xSi$, a bulk metallic magnet derived from doping the narrow gap semiconductor FeSi, shares the very high anomalous Hall conductance of (GaMn)As. This similarity demonstrates that it is productive to consider transition metal monosilicides as a potential alternatives to the Mn doped II-V and II-VI semiconductors for spintronics.

Magnetism underlies many technologies, ranging from motors to data storage. The large transverse voltage that develops in magnets when exposed to external magnetic fields is a useful metric for magnetic materials. However, little understanding of the effect and categorization of materials has been accomplished. In this work we have not only identified a useful class of materials for future technologies (silicon-based magnetic semiconductors), but have identified the physical mechanism creating the effect. The result is a useful separation of materials demonstrated by the figure. Furthermore, because of the wide availability of cheap and precisely controlled light sources (such as semiconductor lasers) and solid state detectors (such as the charge coupled devices in digital cameras) scientists and engineers have a large interest in optical control and read-out of magnetic states. Our accomplishment, highlighted on the second slide, is the discovery of a material whose optical reflectivity (shininess) not only changes noticeably on becoming magnetized, but which – contrary to previous experiment, actually becomes duller rather than shinier. An exotic quantum effect is actually responsible for this behavior in the material, which is easily fabricated and silicon-based.

Quantum Criticality and Magnetic Semiconductors

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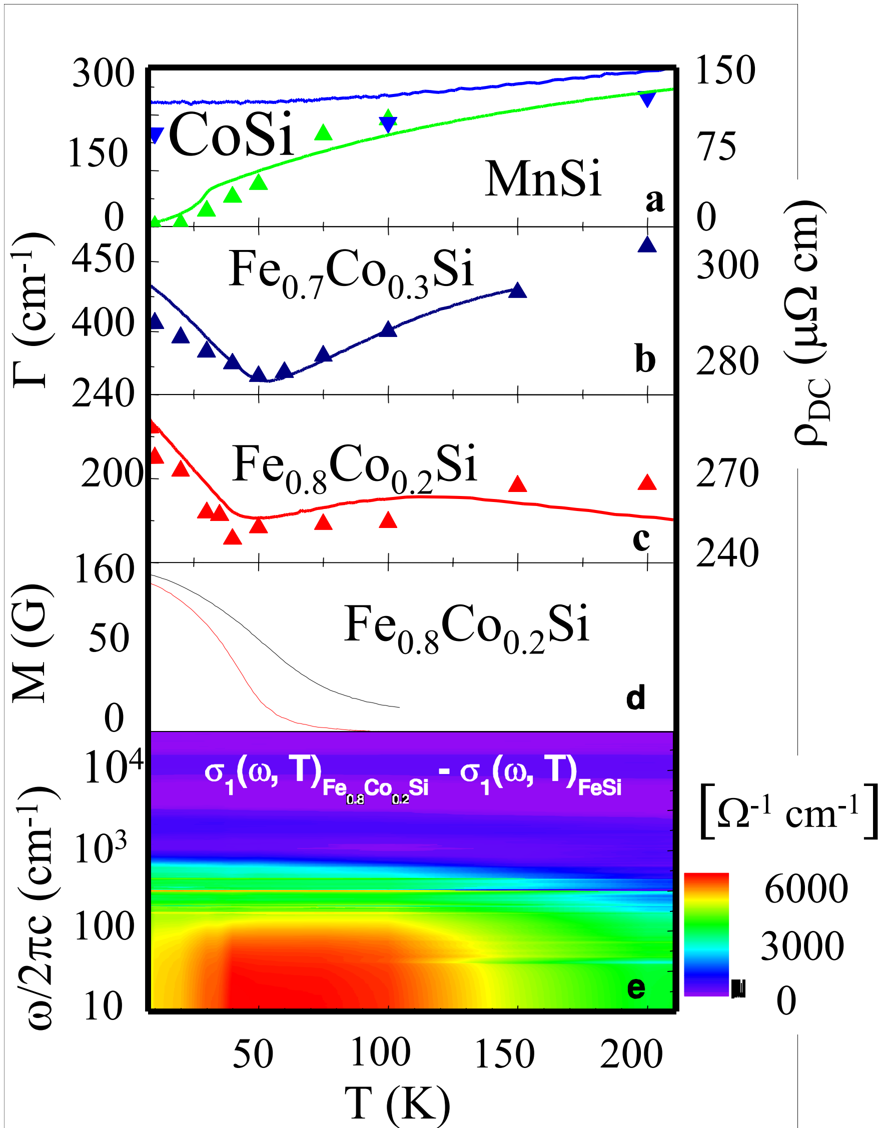

Broader impact: Our ability to manipulate the magnetic moments of electrons to the same extent that we can their charge in modern device technologies underpins the nascent technology of spintronics. This research explores the fundamental question of how a paramagnetic semiconductor can be modified to exhibit ferromagnetic and metallic properties and searches for silicon-based materials for use in spintronics. This figure displays the optical spectrum of a magnetic semiconductor and suggests that magneto-optical devices may be possible.

Education: Undergraduate students Robert Anderson, Jakob Duran, Jon Hanson, Jon Hefner (computer science), Dung Lee, Becky Lefebvre, Andrew Morrow, Margaret Reaves (Chem E), Christopher Weaver, and Matthew Wolboldt and graduate student Song Guo all contribute to this research.